PHYTOTOXICOLOGY SURVEY REPORT: PAH CONTAMINATION ON IVY AVENUE TORONTO (1995)

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BACKGROUND:

In 1994, a resident of Ivy Avenue (Greenwood Ave. and Gerrard St. area) in the City of Toronto, requested an investigation by the Ministry of Environment and Energy (MOEE). The resident was concerned that certain materials handled or stored on a nearby industrial property may have migrated onto her property. The property identified by the resident was occupied by Heather and Little Limited, a company specializing in the installation of roof coverings on commercial and institutional buildings.

The investigation was conducted by the MOEE Phytotoxicology Section. It revealed that the soil on the resident's property contained polycyclic aromatic hydrocarbons (PAHs) at concentrations that were substantially higher than what would be expected as a result of atmospheric deposition from the ubiquitous sources of these chemicals in an urban area.

To determine if soil contamination by PAHs was more widespread, the MOEE Toronto District Office requested a broader investigation by the Phytotoxicology Section. Heather and Little remained the suspected source in this investigation primarily because PAHs are major constituents of coal tar pitch, a material used extensively in flat roof construction in the past.

INVESTIGATION AREA:

Heather and Little Limited is located at 36 Wagstaff Drive, in the City of Toronto. This location houses company offices and a workshop. Approximately 100 metres west of the office/workshop building, the company occupies a property for the storage of roofing materials and equipment. The storage yard measures about 45 by 38 metres. There are no permanent structures in this yard.

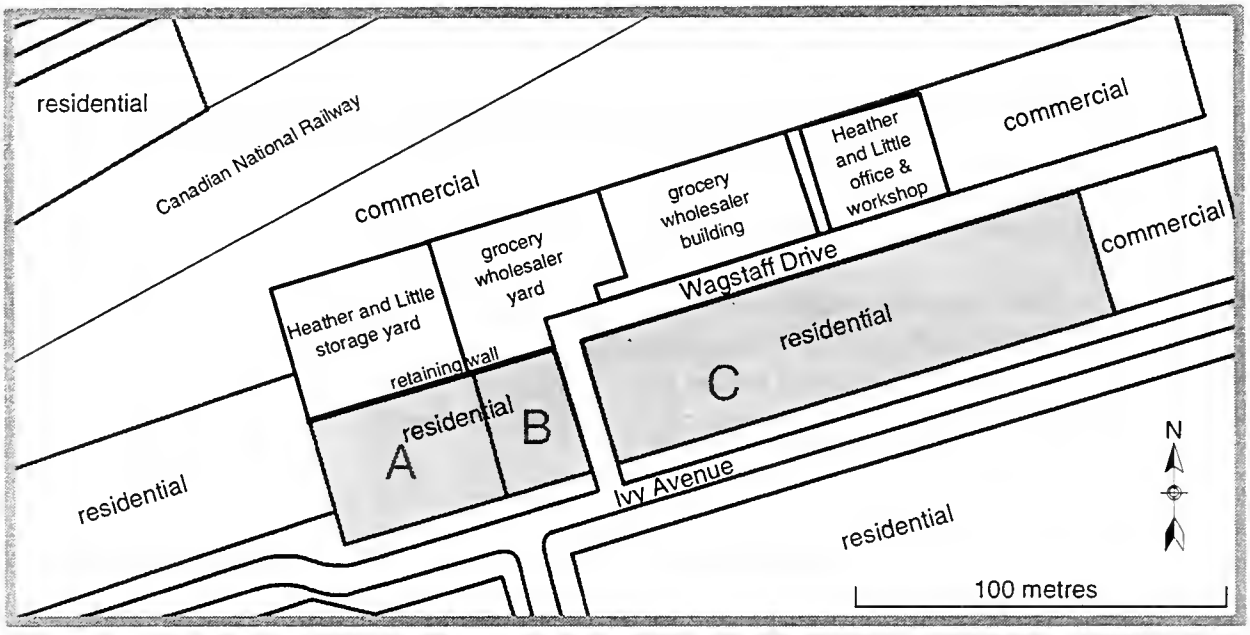
The properties in the neighbourhood are occupied primarily by commercial or light industrial establishments. Ivy Avenue is a residential street running parallel to and immediately south of Wagstaff Drive. Seven of the Ivy Avenue properties have rear yards bordering the Heather and Little storage yard, and four additional properties border a storage yard occupied by a grocery wholesaler. The property line between the storage yards and these eleven Ivy Avenue properties contains a unique feature. A vertical retaining wall has been constructed with rocks contained within a wire mesh basket. Fill material has been added on the north side of this wall to create the level storage yards. The wall ranges in height from about five metres above the grade of the most westerly of the adjacent residential properties, to less than one metre above the grade of the most easterly property.

The remaining properties in the east end of Ivy Avenue back onto Wagstaff Drive, which is much more like a laneway than a city street. Figure 1 consists of a map identifying the features relevant to this investigation.

INVESTIGATION PROCEDURES:

This investigation was performed on October 11, 1995, subsequent to a meeting between the author/investigator and Steve Carrasco of the MOEE Toronto District office, and Stephen Bell of Heather and Little.

Figure 1: Urban Area in Vicinity of Heather and Little Limited, Toronto



A walking tour of the neighbourhood was conducted to identify potential sampling sites. It was decided to concentrate the sampling on residential properties that adjoined the Heather and Little storage yard. The hypothesis for this investigation was that the PAH contamination identified in the soil of one of the residential properties in 1994, was due to migration of these chemicals from the Heather and Little storage yard.

Attempts to contact residents of the homes proved to be generally unsuccessful, as knocks on the front doors were not answered. Where access was feasible and the property contained suitable sampling areas, the investigator proceeded into the rear yards to collect samples.

A total of eight different properties were sampled in this investigation. These can be split into three categories. Category A contains properties whose rear boundaries abut the retaining wall at the Heather and Little storage yard. Category B contains properties that abut the retaining wall at the grocery wholesaler yard. Category C contains properties that are located away from any possible influence by runoff from the Heather and Little storage yard.

As mentioned previously, there were seven properties bordering the Heather and Little yard and four properties bordering the grocery wholesaler yard. Of these, four from Category A and one from Category B were sampled. The remaining either did not have suitable sampling surfaces, or could not be accessed. Category C could consist of any number of potential properties. For this investigation, three properties on Ivy Avenue abutting Wagstaff Drive were designated Control properties and sampled.

Figure 1 contains the characters **A**, **B** and **C** identifying locations of residential properties in the three categories described above. Details, such as property addresses, are being specifically excluded in this report to maintain confidentiality about specific conditions discovered on these private properties.

The sampling sites on each property were established to test the hypothesis that the source of PAHs was migration from the Heather and Little storage yard. These contaminants could theoretically be carried from the elevated storage yard, down the retaining wall, and be deposited in the soil of the neighbouring properties. Under this scenario, one would anticipate the highest concentrations of PAHs next to the retaining wall.

Properties in the **A** and **B** categories had three sampling locations established in their rear yards. The first of these (Location Type 'a') was a one metre wide strip, extending across the width of the yard, at the extreme north end of the property. This placed it adjacent to the retaining wall. The second location (Location Type 'b') was a similar strip about one or two metres south of the first. The third location (Location Type 'c') was still in the rear yard, but as far away as possible from the retaining wall. These locations were typically about 10 to 12 metres from the wall. At one property, the first sampling location was not suitable for sampling.

Properties in the **C** category were not differentiated by Location Type. The whole of the rear yard that had exposed soil was included in the sampling. These properties were designated "Control" locations and were intended to provide information on background concentrations of PAH compounds in the neighbourhood.

Sampling was conducted with an Oakfield™ soil corer. This device removes a two-centimetre cylindrical core when inserted into the soil. In this investigation, the top five centimetres of soil was sampled. At each sampling location, about ten such cores were collected from randomly distributed points. These cores were placed into a stainless-steel bowl, homogenized with stainless-steel spoon and transferred to an amber glass jar with aluminum foil cap liner. Prior to collecting each sample, all equipment was washed in a detergent solution, rinsed with deionized water, and then successively rinsed with acetone and hexane. The jars had been previously cleaned by the analytical laboratory.

The samples were then delivered to the MOEE Laboratory Services Branch for analysis of selected polycyclic aromatic hydrocarbons.

RESULTS:

The laboratory has the capability for routine determination of 16 different PAH compounds in a soil matrix. The results of the analyses are reported in Table 1. Also reported are the total concentrations of the PAH compounds in each soil sample. These totals were determined by summing the concentrations of individual PAHs, without any adjustments for those data that were flagged with the analytical qualifiers <T and <W.

This table also contains the OTR_{98} guideline concentrations for PAHs in soil in old urban parkland locations. An OTR_{98} guideline represents the upper end of the background concentration range of an element or compound in Ontario soil that has not been exposed to a point source of contamination. These guidelines are not available for all land-use categories. Specifically, there are no OTR_{98} guidelines for urban residential properties. Therefore, urban parkland guidelines are substituted. Appendix 1 contains an explanation of OTR_{98} guidelines.

Table 1: Polycyclic Aromatic Hydrocarbon Concentrations (ng/g dw) in Soil near Heather and Little Limited, Toronto

Property Category	A	A	A	A	A	A	A	A	A
Property Number	1	1	1	2	2	2	3	3	3
Location Type	a	b	c	a	b	c	a	b	c
Naphthalene	20 <W	40 <T	40 <T	280	160	60 <T	4700	2500	1700
Acenaphthylene	20 <W	20 <W	20 <W	40 <T	60 <T	20 <W	260	120	460
Acenaphthene	20 <W	60 <T	40 <T	520	460	60 <T	7400	5000	3300
Fluorene	20 <W	60 <T	40 <T	780	680	60 <T	15000	8100	5400
Phenanthrene	280	820	600	6400	5800	960	160000	110000	130000
Anthracene	40 <T	160	120	2000	1600	160	26000	16000	12000
Fluoranthene	1000	2300	1300	9600	9400	2000	170000	120000	170000
Pyrene	960	1900	1100	7500	7500	1600	130000	96000	130000
Benzo(a)anthracene	440	980	560	5000	4900	780	45000	30000	24000
Chrysene	580	1200	680	4200	4500	960	46000	31000	27000
Benzo(b)fluoranthene	640	1400	800	4400	4900	1100	18000	32000	29000
Benzo(k)fluoranthene	260	560	320	2300	2400	440	19000	13000	12000
Benzo(a)pyrene	440	960	560	4200	4300	760	36000	24000	21000
Benzo(g,h,i)perylene	320	640	400	2400	2700	520	23000	14000	12000
Dibenz(a,h)anthracene	80 <T	160 <T	80 <T	640	640	120 <T	5100	4000	3300
Indeno(1,2,3-cd)pyrene	360	720	440	2800	3000	560	23000	16000	14000
Total	5480	11980	7100	53060	53000	10160	728460	521720	595160

Table 1:(cont.) **Polycyclic Aromatic Hydrocarbon Concentrations (ng/g dw) in Soil near Heather and Little Limited, Toronto**

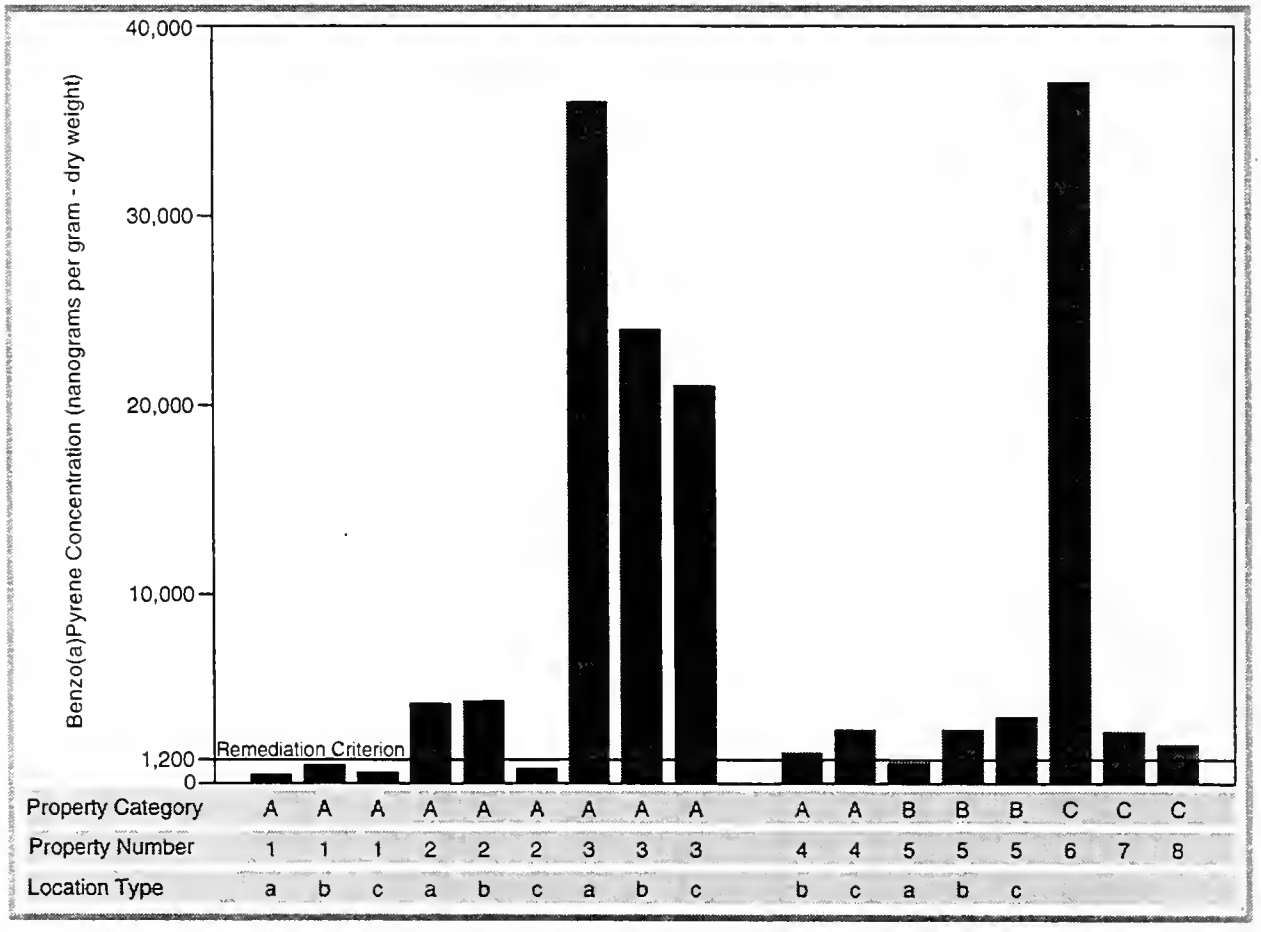
Property Category	A	A	B	B	B	C	C	C	OTR98
Property Number	4	4	5	5	5	6	7	8	
Location Type	b	c	a	b	c	na	na	na	
Naphthalene	80 <T	60 <T	40 <T	100	80 <T	3800	60 <T	60 <T	75 <T
Acenaphthylene	40 <T	400	40 <T	40 <T	100	400	40 <T	40 <T	47 <T
Acenaphthene	160	100	80 <T	340	180	4900	160	140	32 <T
Fluorene	160	80 <T	100	360	180	9700	180	160	39 <T
Phenanthrene	2000	1100	1400	3500	2900	200000	2800	2600	310
Anthracene	420	400	320	940	540	16000	520	460	58 <T
Fluoranthene	3900	5600	2900	5900	6000	250000	5100	4900	560
Pyrene	3300	5000	2400	4800	5300	200000	4300	4100	490
Benzo(a)anthracene	1700	2900	1200	3000	3300	100000	2600	2000	360
Chrysene	2000	3400	1400	3500	4100	120000	3200	2500	350
Benzo(b)fluoranthene	2300	4500	1600	4100	5100	130000	3900	2900	300
Benzo(k)fluoranthene	880	1600	600	1500	1900	21000	1400	1100	260
Benzo(a)pyrene	1600	2800	1100	2800	3500	37000	2700	2000	300
Benzo(g,h,i)perylene	1000	1800	720	2000	2600	24000	1900	1400	280 <T
Dibenz(a,h)anthracene	280	520	200	480	560	5800	440	320	77 <T
Indeno(1,2,3-cd)pyrene	1200	2100	840	2300	2900	27000	2200	1600	230 <T
Total	21020	32360	14940	35660	39240	1149600	31500	26280	

na = not applicable
<W = analytical detection limit, response = 0
<T = trace concentration, interpret with caution

The data in this table are stratified by Property Category, Property Number, and Location Type. Property Number is used to identify individual properties. Thus, the sample designated 'B5a' was collected near the retaining wall at Property Number 5, which was a property with the grocery wholesaler yard beyond the wall.

Data for one of the PAH compounds, namely benzo(a)pyrene B(a)P, was selected for graphical presentation in Figure 2. B(a)P is known to have carcinogenic properties, which might make it the subject of the greatest amount of interest. Figure 2 is a histogram representing the concentrations of B(a)P in the soil samples collected during this investigation. The data are presented using the same type of stratification used in Table 1. A horizontal line near the bottom of the figure represents the B(a)P concentration of 1,200 nanograms per gram. This value is the MOEE generic Soil Remediation Criterion for B(a)P in surface soil of residential properties in a non-potable groundwater situation. A Remediation Criterion is not an action level, and an exceedence does not indicate a clean-up is automatically conducted. The Remediation Criteria were developed to guide the clean-up of contaminated sites when land use is changing (eg., an industrial property is being redeveloped for residential or park use). Appendix 2 describes the derivation and significance of the Remediation Criteria.

Figure 2: Benzo(a)Pyrene in Soil of Residential Properties near Heather and Little Limited, Toronto



Note: The Remediation Criterion is not an automatic clean-up value, see Appendix 2.

DISCUSSION:

The PAH concentrations in soil on these residential properties exceed what might be expected in an old urban area subjected to decades of atmospheric deposition of PAHs emitted by various mobile and stationary combustion sources. This is particularly the case at the properties with the highest concentrations. One of the first actions to be taken upon receiving these data, was to contact the analytical laboratory to verify that the data were valid. This verification was provided.

The source(s) of the PAHs are more likely to be a direct application of some material containing high concentrations of these chemicals at these residential properties, or migration from a nearby location. Because these high concentrations are not restricted to one property, some isolated activity such as import of contaminated soil by a homeowner is unlikely to be the sole source of this contamination. At this time, however, no potential source or contamination mechanism should be ruled out.

This investigation was designed to test the hypothesis that the Heather and Little storage yard was a source of the PAHs encountered during a complaint investigation in 1994. This was a reasonable theory given that this roofing company has operated at the present location for decades and the roofing industry used coal tar pitch in roofing applications. Coal tar pitch is composed primarily of PAH compounds. Coal tar pitch is no longer used by the industry, having been replaced by asphalt materials. Asphalt does contain PAHs, but only at a few parts-per-million concentrations.

While there is a tendency for samples collected at the retaining wall of the Category A properties to have higher PAH concentrations, this pattern is not consistent. There are also moderately elevated concentrations on the Category B and two of the Category C properties, and the very high concentrations on the third Category C property. The Category B and C properties do not presently border on any part of the Heather and Little operation. Even though Heather and Little is the suspected source, in the absence of a demonstrated mechanism of contamination and without additional data derived from more sampling, the current or historical operations of this company cannot be confirmed as having caused the local soil PAH contamination.

Another feature of these data is the very large differences in soil PAH concentrations over very short distances. For example, Properties 2 and 3 are adjacent to each other, yet total PAH concentrations differ by an order of magnitude. Currently the only plausible explanation that can be offered for this phenomenon is to ascribe these differences to interventions by homeowners. The sampling procedures collected only the top five centimetres of soil. If a homeowner brought in topsoil either to improve a garden or through sodding, then the layer of soil that was sampled would include this imported, presumably uncontaminated material.

CONCLUSIONS:

Several properties on Ivy Avenue in the City of Toronto contain surface soil with moderately elevated to highly elevated polycyclic aromatic hydrocarbon concentrations. The origin of this material could not be determined by this investigation. Since PAHs are major constituents of coal tar pitch, and coal tar pitch was used in roofing applications in the past, the

Heather and Little operation remains the likely source of the soil PAH contamination, but this cannot be confirmed without additional sampling. In addition to this sampling, archival research should be conducted to determine whether some industrial and commercial enterprises operating in this area in the past could have been responsible for this type of contamination.

APPENDIX 1

Derivation and Significance of Ontario Ministry of Environment and Energy (MOEE) "Ontario Typical Range" of Chemical Parameters in Soil

The MOEE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (the OTR_{98} is the actual guideline number) may indicate the presence of a potential point source of contamination.

The OTR_{98} represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOEE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOEE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concern even when a result falls within the guideline. For example, if all of the results from a survey are close to the OTR98 this could indicate that the local environment has been contaminated above the anticipated average, and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. As a result, it must be stressed that values falling within a specific OTR_{98}

should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans. Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types (eg. vegetation). For more information on the MOEE's OTR program, refer to *Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags, and Snow. Version 1.0a, April 1994*, Ontario Ministry of Environment and Energy, PIBS 2792, ISBN 0-7778-1979-1.

APPENDIX 2

Derivation and Significance of the Ontario Ministry of Environment and Energy (MOEE) Soil Remediation Criteria

The MOEE Soil Remediation Criteria have been developed to provide guidance in cleaning up contaminated soil. They are not action levels, in that an exceedence of one or more of the criteria does not automatically mean that a clean-up must be conducted.

A site clean-up may be conducted when a contaminated property is sold and/or the land use is changed. For example, the owner of an industrial property who plans to sell his/her land to a developer who intends to build residential homes can use the Remediation Criteria to clean up the soil to meet the residential land use criteria. This will allow the site to be reused for residential land-use without concern for adverse effects.

When contamination is found at a site where a change in land-use is not planned, the generic criteria may be used to assist in making decisions about adverse effects and the need for remediation. This is somewhat different from the previously described situation where a decision to change the land-use has already been made and the level of remediation required to rule out the potential for adverse effects is established by the new land use.

Decisions on the need to undertake remedial action when the generic criteria are exceeded, and where the land use is not changing, require an examination and consideration of factors such as:

- the demonstrated presence or likelihood of an adverse effect (on and off property);
- an understanding of the type of protection provided by the generic criteria gained through knowledge of the exposure pathways and receptors which were considered in the development of the generic criteria, and through understanding how that combination of pathways and receptors relate to those which could be found at the site;
- an understanding of the quantitative relationship between dose and health response for sensitive receptors from all exposure pathways, including the safety and uncertainty factors which have been used in the development of the generic criteria;
- an understanding of the environmental characteristics of the contaminant (i.e. environmental fate and mobility of the contaminants) and of the site conditions which could influence the migration of the contaminant and its exposure and response characteristics (e.g. soil type, proximity to water table, depth to bedrock, etc.).

In each case, the decision to undertake or not undertake site remediation action should entail an assessment and understanding of these and possibly other factors specific to the site in question.

When the decision is made that remedial action is needed, the generic criteria can be used

as remediation targets or goal values. The choice of using the background criteria or site specific criteria developed via a Site Specific Risk Assessment also remains available for consideration.

The Soil Remediation Criteria are effects-based concentrations set to protect against the potential for adverse effects to human health, ecological health, and the natural environment, whichever is the most sensitive. By protecting the most sensitive parameter the rest of the environment is protected by default. There are different Soil Remediation Criteria for soil texture, soil depth, and ground water use. The criteria have also been established so that there will not be a potential for adverse effects through contaminant transfer from soil to indoor air, from ground water or surface water through release of volatile gases, from leaching of contaminants in soil to ground water, or from ground water discharge to surface water. However, use of these criteria may not ensure that corrosive, explosive, or unstable soil conditions will be eliminated.

The Remediation Criteria were developed from published U.S. EPA and Ontario environmental data bases. Currently there are criteria for about 25 inorganic elements and about 90 organic compounds. Criteria were developed only if there were sufficient, defendable, effects-based data on the potential to cause an adverse effect. All of the criteria address human health and aquatic toxicity, but terrestrial ecological toxicity information was not available for all elements or compounds. The development of Soil Remediation Criteria is a continuous program, and criteria for more elements and compounds will be developed as additional environmental data become available. Similarly, new information could result in future modifications to the existing criteria.

For more information on the Remediation Criteria please refer to the *Guideline for Use at Contaminated Sites in Ontario. Revised December 1996*, Ontario Ministry of Environment and Energy, PIBs 3161E01, ISBN 0-7778-5905-X.